4K96-54

THE 1996 NORTON SOUND RED KING CRAB TRAWL SURVEY

By

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Regional Information Report[1] No. 4K96-54

Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
211 Mission Road
Kodiak, Alaska 99615

December 1996

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AUTHORS

Each author is a fishery biologist for the Alaska Department of Fish and Game (ADF&G), Commercial Fisheries Management and Development Division. S. Forrest Blau specializes in king crab research, James Blackburn is the database manager for the Westward Region, and Leslie J. Watson works for the Bering Sea Test Fish Program.

ACKNOWLEDGMENTS

The cooperation and effort of the chartered vessel owner, Mrs. Peggy Dyson and survey crew, James Kasner, Scott Weismantel, Mike Sparks, and Don Andrews made the survey go smoothly from start to finish. ADF&G biologists Betsy Brennan and Peter J. Rob from Nome participated in all aspects of the biological sampling and data entry on the survey, thereby contributing to the success of the survey. Charlie Lean, ADF&G Area Fisheries Management Biologist in Nome, selected stations to fish, provided personnel for the charter, and logistical support before and after the charter. Jeff Bromaghin, ADF&G biometrician in Anchorage provided female red king crab size at matruity analysis and assisted in resurvey planning. Doug Pengilly, Westward Region research supervisor, began initial Norton Sound survey planning and budgeting and produced several figures in this report. Donn Tracy, Bering Sea Crab Test Fish Program project leader, procured the trawl nets and doors, and administered the charter vessel contract. Ivan Vining, Westward Region biometrician provided the figure with box plots. Gary Mundell, Gary Walters, and Rich MacIntosh from National Marine Fisheries Service (NMFS) provided species codes, previous survey results, and snail shell collections, respectively, which proved very useful on the survey.

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INTRODUCTION

Norton Sound Section (Q_3), a portion of the Bering Sea king crab management area, includes all waters east of 168° W longitude between the latitudes of Cape Romanzof and Cape Prince of Wales (ADF&G 1994.) Subsistence use of red king crabs has long been practiced and occurs primarily through the ice during winter (Lean and Brennan 1995). Commercial fishing seasons for red king crabs occur in two periods: (1) July 1 - September 3 (summer season); and (2) November 15 - May 15 (winter season).

The Norton Sound commercial red king crab fishery began in 1977 (Lean and Brennan 1995). Summer commercial fishery harvests have averaged less than 250,000 crabs (750,000 pounds) annually, from a high of about 1 million crabs in 1979 to a low of 25,000 in 1992. There was no summer commercial fishery in 1991. The winter commercial fishery is nominal, at an average of 2,582 crabs annually since 1978. The 1978 harvest was the highest at 9,625 crabs, followed by a rapid decline from 1979 to 81. Modest increases were noted from 1985 to 87, followed by significant gains in the early 1990s, and culminating in a harvest of 7,538 crabs in 1995. Harvests of king crabs in the winter subsistence fishery have ranged from lows of 200-400 crabs to substantial harvests of over 12,000 crabs. In recent years, the harvest has been about 4,000 crabs. Major factors limiting the winter commercial and subsistence fisheries are poor ice conditions and shifts in the distribution of crabs.

Summer pot surveys of the Norton Sound red king crab stock were conducted by ADF&G from 1980-82 and in 1985 and were designed for two primary purposes: (1) to provide annual distribution, relative abundance and size class profiles during years that NMFS did not conduct assessment surveys; and (2) to provide preseason information to fishery managers regarding stock size and structure (Lean and Brennan 1995).

Trawl assessment surveys have been conducted in Norton Sound triennially from 1976 to 1991 by NMFS to provide distribution and abundance of demersal fish and invertebrates for fishery managers. Results from the six NMFS surveys are summarized in Wolotira et al. (1977), NMFS (1982), Sample and Wolotira (1985), Stevens (1989), Stevens and MacIntosh (1986), and Stevens (1992). Due to federal budgetary constraints, responsibility for future trawl surveys was transferred to the ADF&G. Red king crab *Paralithodes camtschaticus* distribution and stock status is the focus of this report.

OBJECTIVES

The eight prioritized objectives for the 1996 Norton Sound red king crab trawl survey as stated in the Project Operational Plan (Blau et al. 1996) are listed below.

I. Survey a portion of Norton Sound for red king crabs and associated marine life for spatial distribution, abundance and population characteristics using a 400 eastern otter trawl. Population estimates of red king crabs will be made from this data using the area-swept

technique (Alverson and Pererya 1969) by ADF&G Alaska-Yukon-Kuskokwim biometrician Jeff Bromaghin and fisheries biologist Lowell Fair.

II. Maintain continuity of previous (1976 to 1991) NMFS trawl survey databases in Norton Sound by using the same station midpoints, grid pattern, and general sampling procedures.

III. Lengths, weights, and other biological data will be taken from all the red and blue king crabs, Pacific halibut, and Pacific cod whenever found in any haul made in Norton Sound.

IV. Each tow will be randomly subsampled by filling one to four baskets of the remaining fish, invertebrates, and debris. Contents of the basket(s) will be sorted to the lowest taxon possible, counted and weighed. Sampling of each haul will be completed prior to bringing the next haul aboard.

V. A total of 58 stations, including 43 core stations and three lower priority tiers of five stations each (15 stations) will be towed unless the weather hampers trawling efforts. If the weather is good, the goal will be to complete an average of six stations per day.

VI. After all 58 stations in objective V have been towed, and if there are additional charter days available for biological sampling, stations will be selected for resurveying by Charlie Lean, Jeff Bromaghin and Lowell Fair based on high catches of red king crabs.

VII. All data will be entered into an electronic database. Data needed for red king crab population estimation by ADF&G AYK biometrical staff (Jeff Bromaghin and Lowell Fair) will be transferred by Kodiak ADF&G staff (Blau, Vining, and Blackburn) no later than November 1, 1996.

VIII. An ADF&G Regional Information Report on the 1996 Norton Sound trawl survey will be completed by Kodiak ADF&G staff by December 31, 1996

METHODS

Trawl Survey Design

Survey Vessel and Crews

Kodiak-based 30.5 m (100 ft) FV *Peggy Jo*, was chartered by ADF&G for the 1996 Norton Sound red king crab trawl survey from August 1-25 at the rate of $3,836 per day ($95,900 total).

Crews onboard the FV *Peggy Jo* were as follows, with ADF&G staff aboard only when trawling occurred in Norton Sound. The charter began and ended in Kodiak.

ADF&G Crew	FV *Peggy Jo* Crew
Forrest Blau - Crew Leader (King Crab Research Biologist), Kodiak	James Kasner - Captain, Kodiak
Jim Blackburn - Assistant Crew Leader (Fishery Biologist and Database Manager), Kodiak	Scott Weismantel - Engineer, Kodiak
Betsy Brennan - Fishery Biologist, Nome	Mike Sparks - Deck Boss & Cook, Kodiak
Peter Rob - Fisheries Monitor, Red King Crab Winter Project Crew Leader, Nome	Don Andrews - Deck Hand, Kodiak

Survey Grid Design and Station Locations

The nonrandom, systematic station location design used by NMFS on their six trawl surveys of Norton Sound (1976 to 1991) was adopted for this survey to provide a comparable survey pattern. A 10 x 10 nmi grid pattern was established for Norton Sound with each 10 x 10 nmi square identified by a station number. Center of each survey station have been standardized using latitude and longitude coordinates that denote where each trawl should begin within a station (Blau et al. 1996) (Figure 1).

Trawl Gear, Towing Time, Speed and Distance

A 400 eastern otter trawl (described in Appendix A) was towed for approximately one half hour at a speed of approximately two knots to cover a target distance of 1.85 km (1 nmi) at each station. This gear was set and retrieved from the net reel by a pair of steel cables from hydraulic deck winches. Navigational equipment consisted of a 800 Northstar[1] GPS/Loran receiver, Simrad EC 222[1] color sounder, and 1050 ECC[1] electronic chart machine loaded with NOAA bathymetric charts. Haul data were recorded by the captain on the Trawl Survey Haul Record form (Appendix B.1). Tows were placed on trawlable substrate near each station's midpoint (Blau et al. 1996). National Oceanic and Atmospheric Administration sailing chart 16206 with survey stations marked on it was available to the captain as a reference tool. Each tow was made in the direction of the prevailing wind and swell while trying to maintain the same depth throughout the tow. Distance and bearing were calculated on the chart machine from the start and stop of the tow locations as determined from the GPS receiver. No adjustments were made to the depths noted on the sounder since diurnal tidal amplitude changes average 1.6 feet (NOAA 1989). Depths were recorded to the nearest 0.1 fm but rounded to the nearest fathom when the data was entered.

Survey Coverage Goals

The goal was to trawl 43 core stations first, followed by the 15 stations in tiers 1, 2, and 3, towed sequentially by tier number (Figure 2). Note that areas shoreward of the dashed line in Figure 2 were closed to commercial king crab fishing July 1 to September 3 by regulation (5 AAC 34.935) (ADF&G 1994).

[1] Reference to trade name does not imply endorsement by ADF&G.

Nonstandard or Untrawlable Stations

Prior to each tow the intended tow location was traversed and trawlability was assessed by the captain. When the bottom was not suitable for trawling the captain searched for trawlable bottom within the station for not more than two hours before abandoning the station.

Resurvey Stations

Resurveying instructions were received from Charlie Lean on August 15, 1996 via radio. First, if stations 78, 79, 80 or 103 produced 10 or more legal male red king crabs per tow, adjacent stations that had not been fished would be surveyed. Second, one day was allotted to resurveying stations 124-126, 151-153, and 178. Third, two days were allocated to resurvey stations 130-134, 157-160, and 183-187, with stations 157, 158, 183 and 184 given top priority (Figure 2). Resurveying of stations would be accomplished by towing as close as possible to the initial tow at each station without crossing the previous tows' path.

Temperature Probe

A submersible temperature recorder, TR-1000 Temperature Recorder (Richard Brancker Research Ltd.[1]) was used to record bottom temperatures for each tow. It was housed in rigid rubber housing and attached to the trawl each morning and detached each evening. Temperatures were recorded every minute once the unit was deployed. Daily temperature profiles were downloaded onto a 486 notebook computer. Bottom temperatures were averaged for each tow and recorded on the Trawl Survey Haul Record form (Appendix B.1).

Catch Handling

While the net was being retrieved, sea stars, fish and crabs were shaken from the net's mouth down to the codend by the vessel crew. Once the codend of the trawl came aboard, a lifting strap was placed around it to which a Port-A-Weigh[1] crane scale was hooked. The codend was raised off the deck and the gross weight of the codend and its contents was recorded. Contents of the trawl were then emptied on deck and the empty codend was reweighed to determine the tare weight. Weights were recorded in kilograms for each tow along with haul number, station number, and date on the Station Catch Record form (Appendix B.2.).

All red king crabs, Pacific halibut *Hippoglossus stenolepis*, Pacific cod *Gadus macrocephalus*, Walleye pollock *Theragra chalcogramma* were picked from each haul prior to subsampling. Their numbers and weights were recorded on the Station Catch Record form as total catch. Fork length measurements were made on all fish and recorded on the Fish Length Frequency form (Appendix B.3). Halibut were not weighed, but their length was converted to its whole weight using a conversion table (IPHC 1991).

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Red King Crabs

Applicable data for each crab captured were recorded in the appropriate column on the Crab Research Data form (Appendix B.4). Carapace length (CL) was measured to the nearest millimeter from the posterior margin of the right eye socket to the midpoint of the rear margin of the carapace (Wallace et al. 1949).

Size Categories. Females were juveniles when they were <72 mm CL, nonovigerous, and had clean pleopodal setae; all others were adults (J. Bromaghin, Alaska Department of Fish and Game, Anchorage, personal communication). Males that measured ≥120.7 mm (4.75 in) carapace width, outside the spines were legal (ADF&G 1994). Sublegal and legal-sized males each were split into two groups. Sublegal males ≤89 mm CL were classed as two or more years from becoming legal size, while those >89 mm CL, but are less than legal size, were classed as prerecruit ones or "ones" (Powell et al. 1983). Recruits included all new-shell legal crabs ≤115 mm CL. Postrecruits were all legal males >115 mm CL and all male anexuviants (skip molt crabs) that had obtained legal width.

Shell-Age Categories. The body part examined to determine the shell "age" of each crab was the ventral side of the coxa of the walking legs (pereopods). For purposes of this report, shell-age classes were defined as follows:

Soft-shell: Crab has molted within weeks. Exoskeleton is still soft and pliable from recent molt.

New-shell-pliable: Coxa and ventral surface of exoskeleton white. Legs easily compressed when pinched (legs contain little meat at this time). Exoskeleton fragile and subject to breakage or puncture when dumped from the trawl. If carapace is removed the gills would be translucent-cream in color. Crabs estimated to have had new exoskeletons for approximately 1-3 months.

New-shell-hard: Coxa and ventral surface of exoskeleton white. Legs mostly full of meat, meri not easily compressed by pinching. If carapace is removed, the gills will be a light cream color. Crabs estimated to have had exoskeletons for 4-12 months.

Old-shell. Distal portion of the ventral coxa is partially or totally rimed with brown scratches or dots. Legs are full of meat, meri not easily compressed when pinched. If carapace is removed, gills will be tan in color from fouling microorganisms. Crabs estimated to have had their exoskeletons for 13-24 months. (Note some crabs classified as old-shell were probably less than a year old but shared the coxa characteristic of old-shell crabs.)

Very old-shell: Distal portion of ventral coxa continuously rimed with black scratches or dots. Legs full of meat, meri not easily compressed when pinched. Tips of dactyls worn round and black. If carapace is removed, gills will be dark gray or dark gray-brown in color from fouling microorganisms. Crabs estimated to have had their exoskeletons for >24 months.

Measuring Shell Hardness With a Durometer. An objective measure of exoskeleton hardness/meat fullness was taken with a durometer (Hicks and Johnson 1991). The tip of the durometer was placed in the middle of the ventral surface of the merus on the right, second walking leg (pereopod) and pressed down until the indicator tip was depressed to the maximum

durometer reading (0-100) for each crab while holding the leg in the air at the joint between the merus and carpus.

Subsampling the Catch

A sample of the remaining catch was shoveled into two plastic baskets. Each subsample consisted of one or two filled baskets (36 cm deep x 42 cm diameter). Basket contents were either combined or separately enumerated. Fish and invertebrates were sorted from debris, identified to the lowest taxon possible, then counted, and weighed on either a 12 kg Universal[1] dial scale or on a 52 kg Chatillion[1] platform scale, then recorded on the Station Catch Record form with a species code (NMFS 1996).

Length frequencies of nontarget fish were taken on an opportunistic basis and recorded on the Fish Length Frequency form. Primary references used to identify fish and invertebrates included: Andriyashev (1954), Wilimovsky (1964), Hart (1973), Baxter (1984), and Kessler (1985).

Data Checking and Entry

Each day, either between tows, or once all towing has been completed, all data forms were checked for accuracy and completeness. Once checked for accuracy the data were entered at sea using Rbase[1] software on a 486 notebook computer. Data was double checked for accuracy at the ADF&G office in Kodiak, then collated into a database named NortonSD.

Radio Schedule and Log

A daily radio schedule was maintained between the captain or ADF&G personnel and the ADF&G Nome office to transmit red king crab catch data, each party recorded information on the Station Summary and Radio Log form (Appendix B.5). Radio logs received in Nome were faxed to Jeff Bromaghin in Anchorage and Doug Pengilly in Kodiak.

Photographic Documentation

To help document the survey (e.g. crew, trawling process, sorting and weighing of trawl caught marine life) both a video (8 mm film) and a 35 mm camera were used. Copies of the video tape (16 mm format) and slides and prints were made as reference tools for the ADF&G offices in Nome and Kodiak.

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Artificial Collectors

In late March and early April 1996, 20 sausage-shaped artificial collectors, or SACs (Blau and Byersdorfer 1994) were deployed through the ice at six different sites near Nome in depths from 7 to 9 fm and from 0.5 to 1.81 nmi offshore (Rob 1996). SACs have been used in Kodiak to collect glaucothoe and postlarval red king crabs. Collectors were sunk to the ocean floor at each site and were equipped with a 90-day galvanic time release device in hopes that they would rise to the surface with an attending marker buoy by July. Charlie Lean asked ADF&G crew to look for this gear during the course of the 1996 Norton Sound trawl survey.

RESULTS

Survey trawling occurred in a 12 day period from August 7 through 18, 1996. A total of 69 successful tows were made, an average of 5.75 tows per day (Table 1). Three additional tows were attempted (stations 177, 184, and 206) but were unsuccessful (ripped nets). Eight other stations were assessed for trawling, but were determined to be untrawlable due to unsuitable bottom (stations 162, 178-twice, 188, 204, 205, 222, and 223) (Figure 2). In total, 81 stations were fished or attempted for an average of 6.75 stations per day.

Average depth, bottom temperature and length of tow were record at each successfully trawled station (Table 1). Average bottom depths towed per station ranged from 6 to 17 fm. Average bottom temperatures went from a low of 5.1°C to 12.4 °C. Station 201 had the shallowest average depth and the highest temperature at any station. Average bottom temperature generally decreased with depth. Temperature profiles reveal a U-shaped trend. Temperatures were the lowest when trawling the bottom; but are higher (forming the sides of the "U") while the trawl was descending or ascending temperatures, and peaking at the ocean surface prior to cooling down before the next deployment (Figure 3). Lengths of tows ranged from 1.18 to 1.90 nmi.

Red King Crabs

Number of Crabs Caught and Length Frequencies

There were 485 red king crabs caught, with males outnumbering females nearly 2:1 (317 males vs. 168 females) (Table 1). There were 1.6 times as many juvenile female red king crabs caught as adult females (106 vs. 65) and sublegals outnumbered legals 3.7:1. Small sublegal males ($\leq$89 mm CL) were four times as abundant as prerecruit ones. Legals were composed of 21% recruits and 79% postrecruits.

Ninety-nine percent of the red king crabs were measured (166 females and 314 males) (Figure 4). izes of females ranged from 23 to 110 mm CL and males from 25 to 173 mm CL. Modal size for each sex was similar; 68 mm CL for females and 71 mm CL for males.

Spatial Distribution and Comparison of Initial vs. Resurvey Stations

Red king crabs were distributed throughout the survey area with the highest catches occurring south of Nome in four adjacent stations (183-186) within the area closed to commercial crabbing (Figures 2, 5, and 6). Catch of red king crabs ranged from 0 to 101 per station (Table 1). At 13 stations no king crabs were caught, and at 46 stations 1-9 crabs were caught; these locations were spread throughout the survey area. Ten to 15 crabs were caught at five stations while the remaining five stations (183-186) included the greatest number of crab catch per station (20 to 101). Two of those stations, 183 and 184, were in the top five producing stations twice, once on the initial survey and again during the resurvey.

The total number of red king crabs caught on the resurvey was slightly less than when the same stations were initially fished (Table 2). There were more juvenile females and sublegal males <89 mm CL caught on the resurvey, but less crabs were caught in every other category. Stations were resurveyed 4 to 11 days after they were initially towed (Table 1).

Shell-Aging and Merus Hardness

The predominant shell age category for both male and female crabs was new-hard, with soft and new-pliable categories constituting ≤10 % of the crabs shell-aged (Table 3). Nineteen percent of the males and no females were categorized as having old or very old exoskeletons. Half of the soft-shelled males were legal-sized. Male skip-molting was observed at notably small sizes: 68 mm CL for old-shell and 89 mm CL for very-old shell crabs.

There was a progressive increase in the median value of durometers from soft to very-old shell categories for all red king crabs (Figure 7). There also was a trend of increasing merus hardness with increasing size. Except for the soft-shell category, each of the other shell age groups have merus hardness values which overlapped from two to four shell age groups. New-hard category made up the dominate shell-age category for both sexes and it also had the widest range of merus hardness values, 9 to 58 (Table 3 and Figure 8). Regardless of size or sex, soft-shell crabs measured near zero in merus hardness.

Seventeen percent of all red king crabs were dead from the impacts of trawling. High mortalities occurred with soft-shell (88%) and new-pliable (68%) crabs, but less than 10% of the new-hard, old, and very old-shell categories were dead (Table 3).

Female Reproductive Condition

Nearly three-quarters of all red king crab females caught were barren with clean pleopodal setae (Table 4). One hundred and three of those barren crabs were juveniles and the remaining 20 adult females occurred in a narrow size range (72 to 79 mm CL). Seventy-seven percent of the females having clutches with embryos were ≥60% full. Embryo color was predominantly purple and all embryos appeared uneyed without empty embryo cases (to the unaided human eye).

Rank Order of Species Sampled by Weight

There were 113 taxa identified from 69 tows which had a combined weight of 21,614.5 kg of marine life (Table 5). The top three species (purple-orange sea star, saffron cod and black-spined starfish) composed 61% of the total weight of all marine life caught. Red king crabs ranked 16th overall by weight. Weights of the marine life per haul ranged from 98 to 880 kg, while subsample (basket) weights ranged from 17.1 to 38.5 kg.

Fish Lengths

There were 1,749 lengths measured from Pacific halibut, starry flounder, saffron cod, walleye pollock, and Pacific cod (Table 6). All halibut and Pacific cod captured were measured. Most halibut (80%) met or exceeded minimum legal size (82 cm). Starry flounders were fairly evenly distributed between 26 and 61 cm. Saffron cod included fish as small as 5 cm up to adult size. Pollock were either very small (11-16 cm) or quite large (62-84 cm).

Miscellaneous

Six locations where the SACs were set in March and April 1996 were visited during the survey but no marker buoys were found. The 90-day release devices degraded in 30 days in a test by ADF&G in Nome during the fall of 1996. The buoys deployed in the spring of 1996 probably rose to the surface and were consequently lost due to the grinding and shear action of ice during break up.

Approximately 204 kg (450 lb.) of saffron cod were retained during the survey and frozen onboard the FV *Peggy Jo* for use in the Nome winter through-the-ice ADF&G red king pot survey.

DISCUSSION

All objectives of the 1996 ADF&G Norton Sound red king crab trawl survey were met. It was the first large scale survey of Norton Sound red king crab stocks by ADF&G since 1985, when king crab pots were used. It also was the first trawl survey since 1991 when NMFS conducted its last trawl survey in Norton Sound. The major difference between the 1996 ADF&G survey and the previous six NMFS trawl surveys (1976 to 1991) was the use of different trawl nets. ADF&G used the smaller 400 eastern otter trawl, while NMFS used the larger 83-112 trawl. The 83-112 trawl had 36 cm (14 in) rollers along its footrope, thus enabling it to fish over rockier and more uneven bottom than the rollerless 400 eastern trawl. The 400 eastern is in direct contact with the ocean floor and is more susceptible to tearing and ripping; yet it tends the bottom more closely and may actually catch more crabs on soft bottom than the 83-112. Although sampling of blue king crabs was a priority on the 1996 survey (Blau et al. 1996) none were caught, probably because seven stations around Sledge Is. were untrawlable with the 400 eastern. Blue king crabs have been caught in that area on previous NMFS trawl surveys using the 83-112 trawl and on

ADF&G pot surveys. Prior to the next ADF&G trawl survey in 1999, buying and using a 83-112 trawl to survey for blue king crabs around selected Sledge Is. stations should be considered.

Due to the large size of survey areas in Alaska and budgetary constraints, ADF&G and NMFS have few opportunities to resurvey portions of an area within days or even weeks of the initial survey. Three days of resurveying during this survey was the first resurveying of a portion of Norton Sound, within the same year and agency. It included the most productive stations for red king crabs and covered an area in total that equaled about half of the area initially surveyed.

The peak of male length frequencies is about 70 mm CL, this cohort may provide an increase in recruit-sized crabs by the 1998 commercial season. The combination of written descriptions and use of the durometer defined and separated the five shell-age categories. Splitting the new-shell category into two (new-pliable and new-hard) is a first for ADF&G but was fashioned from shell-age categories used by NMFS for many years. By having two new-shell categories, biologists are better able to discern the portion of new-shell crabs that have molted in the last three months. New-pliable crabs are more susceptible to damage from trawls, pots, or handling than new-hard crabs, and commercial fishing season start or ending times could be adjusted to minimize those cumulative effects (Blau 1996). The 1996 survey revealed that half the soft-shell males were legal-sized and several damaged males had thick "double-skins" (a condition which exits prior to molting and makes the epidermis of processed crab meat less desirable for eating). Durometer data may be useful to the local fishery manager during future surveys. A few days prior on September 3, the commercial season's regulatory end, the only processor of Norton Sound red king crabs requested that the season be shut down due to the high percentage of crabs with double-skins (Charlie Lean, Alaska Department of Fish and Game, Nome, personal communication). Charlie Lean also remarked that the molting period for legal-sized red king crabs began unusually early.

Identification, counting and weighing of species in each haul was done on the 1996 trawl survey in a manner consistent with previous NMFS trawl surveys to provide continuity in general stock assessment methods and data collection procedures so that comparisons could be made regarding species composition from year to year. Fourteen of the top 20 taxa (ranked by weight) from the 1988 and 1991 NMFS and 1996 ADF&G Norton Sound trawl surveys were the same. Purple-orange seastars and saffron cod were the dominant species in each of the three surveys. Red king crabs have remained at about the same ranking during the above mentioned three surveys, while Pacific halibut ranking has steadily moved up from 51st in 1988, to 21st in 1991, and to 5th in 1996. Species of potential commercial value in Norton Sound may include: starry flounder, Pacific halibut, green sea urchin, walleye pollock and various shrimp species.

The area formed to protect subsistence-targeted red king crabs is closed to commercial red king crab harvest July 1 thru September 3 (Figure 2). That area contained the highest catches of red king crabs on both the initial and resurvey during the 1996 Norton Sound trawl survey. The concept of providing sanctuaries for commercially harvested crab species may be a good strategy throughout Alaska. It may be advisable to test if areas closed to commercial harvest produce less variation in recruitment over time.

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Table 1. Station data and the number of red king crabs, by sex categories, caught on the Norton Sound red king crab trawl survey conducted by the Alaska Department of Fish and Game, August 1996. Resurveyed stations are noted in bold.

		Station Location				Ave.	Bottom	Tow	Station			Males				
		N. Latitude		W. Longitude						Females		Sublegals		Legals		
Station[a]	Day	Deg.	Min.	Deg.	Min.	Compass Heading	Depth (fm)	Temp. (°C)	Length (nmi)	Grid Area (nmi^2)	Juveniles[b]	Adults[c]	≤89mm CL	Ones[d]	Recruits[e]	Postrecruits[f]	Total
78	15	63°	40.15'	164°	59.96'	91°	7	10.5	1.31	100	0	0	0	0	0	0	0
79	15	63°	41.12'	165°	22.78'	131°	9	9.5	1.31	100	0	1	0	0	0	0	1
80	15	63°	41.08'	165°	44.17'	155°	11	8.2	1.21	100	0	0	0	0	0	1	1
81	14	63°	39.47'	166°	08.70'	50°	13	7.3	1.26	100	0	0	0	0	0	0	0
82	14	63°	41.43'	166°	27.42'	174°	14	6.9	1.28	100	0	0	0	0	0	1	1
103	15	63°	48.01'	164°	56.70'	336°	8	10.2	1.27	100	0	0	0	0	0	0	0
104	15	63°	49.55'	165°	17.20'	277°	9	9.1	1.31	100	0	1	0	0	0	0	1
105	15	63°	49.79'	165°	43.63'	307°	10	8.5	1.41	100	1	1	1	1	1	1	6
106	14	63°	49.02'	166°	04.91'	337°	13	7.9	1.32	100	0	0	0	1	1	11	13
107	14	63°	51.36'	166°	31.85'	120°	16	6.2	1.27	100	0	0	0	0	1	2	3
123	8	64°	01.31'	162°	17.73'	218°	8	6.5	1.50	100	1	1	0	2	2	0	6
124	8	63°	59.71'	162°	38.77'	262°	9	7.3	1.34	100	0	0	0	1	0	2	3
124	**16**	**63°**	**59.80'**	**162°**	**44.22'**	**86°**	**9**	**9.2**	**1.30**	**100**	**0**	**1**	**0**	**0**	**0**	**0**	**1**
125	9	64°	00.62'	163°	03.79'	219°	9	8.1	1.70	100	0	0	0	2	1	1	4
125	**16**	**63°**	**58.89'**	**163°**	**11.44'**	**38°**	**9**	**8.3**	**1.31**	**100**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
126	9	63°	59.81'	163°	25.98'	279°	10	8.3	1.80	100	0	0	0	0	0	1	1
126	**16**	**63°**	**59.68'**	**163°**	**31.07'**	**82°**	**10**	**8.6**	**1.21**	**100**	**1**	**0**	**0**	**0**	**0**	**0**	**1**
127	10	64°	00.08'	163°	49.96'	270°	9	9.5	1.37	100	0	1	1	0	0	0	2
128	10	63°	58.81'	164°	09.06'	330°	8	10.1	1.30	100	0	0	0	1	0	1	2
129	10	63°	59.32'	164°	34.82'	n/a	9	9.9	1.42	100	0	0	0	0	0	0	0
130	10	63°	59.47'	164°	57.30'	318°	8	10.3	1.43	100	5	1	9	0	0	0	15
130	**15**	**64°**	**01.37'**	**165°**	**01.60'**	**139°**	**9**	**10.8**	**1.23**	**100**	**4**	**0**	**3**	**0**	**0**	**0**	**7**
131	11	64°	00.25'	165°	21.18'	169°	8	8.8	1.37	100	0	2	1	0	0	0	3
131	**15**	**63°**	**58.17'**	**165°**	**22.67'**	**350°**	**9**	**9.9**	**1.21**	**100**	**1**	**0**	**0**	**0**	**0**	**3**	**4**
132	11	63°	59.41'	165°	41.50'	297°	10	8.4	1.32	100	1	0	2	3	0	0	6
132	**17**	**64°**	**00.42'**	**165°**	**45.65'**	**120°**	**10**	**8.5**	**1.30**	**100**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
133	11	64°	00.99'	166°	07.17'	159°	11	7.5	1.26	100	0	0	1[g]	2	0	2	5
133	**17**	**63°**	**59.28'**	**166°**	**05.35'**	**344°**	**11**	**7.9**	**1.20**	**100**	**0**	**0**	**2**	**2**	**0**	**0**	**4**

-Continued-

Table 1. (page 2 of 3)

		Station Location				Ave.	Bottom	Tow	Station			Males				
		N. Latitude		W. Longitude						Females		Sublegals		Legals		
Station[a]	Day	Deg.	Min.	Deg.	Min.	Compass Heading	Depth (fm)	Temp. (°C)	Length (nmi)	Grid Area (nmi^2)	Juveniles[b]	Adults[c]	≤89mm CL	Ones[d]	Recruits[e]	Postrecruits[f]	Total
134	11	63°	59.76'	166°	27.92'	294°	15	7.0	1.24	100	0	0	0	0	0	0	0
134	**17**	**63°**	**59.97'**	**166°**	**28.33'**	**297°**	**15**	**6.5**	**1.21**	**100**	**0**	**0**	**0**	**0**	**2**	**1**	**3**
135	14	64°	00.11'	166°	52.25'	166°	17	5.1	1.42	100	0	0	0	0	0	0	0
150	8	64°	11.32'	162°	19.63'	175°	9	6.1	1.40	100	0	2	0	0	0	0	2
151	8	64°	08.60'	162°	39.28'	325°	11	5.9	1.47	100	3	6	0	0	0	1	10
151	**16**	**64°**	**08.60'**	**162°**	**39.50'**	**301°**	**11**	**7.3**	**1.18**	**100**	**0**	**0**	**1**	**0**	**0**	**0**	**1**
152	9	64°	10.57'	163°	00.79'	249°	13	6.7	1.48	100	0	1	0	0	0	0	1
152	**16**	**64°**	**09.85'**	**163°**	**03.66'**	**252°**	**13**	**7.1**	**1.21**	**100**	**0**	**1**	**0**	**0**	**0**	**0**	**1**
153	9	64°	09.34'	163°	26.87'	304°	10	9.4	1.50	100	0	0	0	0	0	0	0
153	**16**	**64°**	**09.62'**	**163°**	**28.82'**	**104°**	**10**	**7.6**	**1.28**	**100**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
154	10	64°	09.12'	163°	48.33'	335°	10	8.6	1.60	100	3	3	3	1	0	1	11
155	10	64°	09.14'	164°	07.87'	295°	9	9.3	1.40	100	0	1	2	0	1	1	5
156	10	64°	09.37'	164°	39.19'	57°	7	9.5	1.90	100	0	0	0	1	0	1	2
157	11	64°	09.87'	164°	57.19'	277°	7	10.1	1.39	100	0	0	1	0	0	0	1
157	**17**	**64°**	**09.91'**	**164°**	**56.11'**	**276°**	**8**	**10.6**	**1.27**	**100**	**0**	**1**	**0**	**0**	**0**	**0**	**1**
158	11	64°	09.93'	165°	17.49'	271°	9	9.3	1.40	100	0	0	0	0	0	0	0
158	**17**	**64°**	**09.95'**	**165°**	**17.86'**	**271°**	**9**	**10.3**	**1.31**	**100**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
159	11	64°	09.78'	165°	42.73'	338°	10	8.6	1.30	100	0	2	1	0	0	0	3
159	**17**	**64°**	**09.01'**	**165°**	**42.15'**	**319°**	**10**	**9.1**	**1.32**	**100**	**1**	**1**	**1**	**0**	**0**	**0**	**3**
160	11	64°	10.13'	166°	04.28'	271°	11	7.9	1.26	100	0	0	3	2	0	2	7
160	**17**	**64°**	**10.06'**	**166°**	**04.31'**	**268°**	**11**	**8.0**	**1.27**	**100**	**0**	**1**	**1**	**0**	**0**	**0**	**2**
161	12	64°	10.72'	166°	29.71'	208°	13	7.1	1.26	100	0	0	3	0	0	5	8
161	**17**	**64°**	**09.02'**	**166°**	**31.09'**	**31°**	**14**	**7.8**	**1.21**	**100**	**0**	**0**	**1**	**2**	**0**	**1**	**4**
176	8	64°	21.31'	162°	17.09'	189°	9	6.5	1.40	100	0	1	0	0	0	0	1
179	9	64°	20.24'	163°	28.22'	99°	9	9.5	1.60	100	1	1	0	0	0	0	2
180	9	64°	18.94'	163°	47.68'	330°	8	10.7	1.70	100	1	2	1	1	0	1	6
181	7	64°	20.49'	164°	10.93'	228°	6	8.7	1.30	100	0	0	0	0	0	0	0
182	7	64°	19.92'	164°	38.26'	86°	8	9.3	1.45	100	0	0	0	0	0	0	0
183	7	64°	19.85'	164°	59.96'	79°	16	8.7	1.19	100	8	3	22[g]	4	3	3	43
183	**18**	**64°**	**19.98'**	**164°**	**59.18'**	**99°**	**17**	**10.2**	**1.40**	**100**	**8**	**4**	**13**	**1**	**0**	**1**	**27**

-Continued-

Table 1. (page 3 of 3)

Station[a]	Day	Station Location N. Latitude Deg.	Min.	W. Longitude Deg.	Min.	Compass Heading	Ave. Depth (fm)	Bottom Temp. (°C)	Tow Length (nmi)	Station Grid Area (nmi²)	Females Juveniles[b]	Adults[c]	Males Sublegals ≤89mm CL	Ones[d]	Legals Recruits[e]	Postrecruits[f]	Total
184	7	64°17.91'		165°10.89'		289°	10	10.0	1.30	100	26	12	45	8	2	0	93
184	**18**	**64°19.69'**		**165°23.89'**		**107°**	**12**	**10.2**	**1.31**	**100**	**1**	**0**	**7**	**3**	**0**	**0**	**11**
185	12	64°20.05'		165°43.90'		93°	11	9.0	1.31	100	1	1	3	0	0	0	5
185	**18**	**64°19.94'**		**165°45.62'**		**96°**	**11**	**10.0**	**1.20**	**100**	**4**	**0**	**14**	**1**	**1**	**0**	**20**
186	12	64°20.00'		166°09.72'		91°	12	7.1	1.26	100	1	1	1	0	0	0	3
186	**18**	**64°20.08'**		**166°10.04'**		**97°**	**12**	**9.1**	**1.23**	**100**	**29**	**9**	**55**	**7**	**1**	**0**	**101**
187	12	64°18.74'		166°29.25'		345°	14	7.3	1.36	100	0	0	0	3	2	1	6
187	**17**	**64°18.74'**		**166°29.40'**		**348°**	**14**	**7.5**	**1.27**	**100**	**2**	**1**	**1**	**2**	**0**	**3**	**9**
201	8	64°29.68'		162°19.02'		59°	6	12.4	1.50	91.2[h]	0	0	0	0	0	0	0
202	7	64°30.64'		163°48.75'		240°	7	10.0	1.35	85.6[h]	0	1	0	0	0	0	1
203	7	64°28.67'		164°15.31'		61°	9	9.1	1.40	82.8[h]	0	1	0	0	0	0	1
										Totals:	103	65	199	51	19	48	485

a Station numbers and approximate locations are the same as those used on National Marine Fisheries Service trawl surveys of Norton Sound from 1976 to 1991.

b Juvenile red king crabs include all females < 72 mm carapace length (CL) that were nonovigerous and had clean pleopodal setae.

c Adult females include all crabs ≥ 72 mm CL and all ovigerous females.

d Prerecruit ones include all males estimated to be one molt from recruit size; greater than 89 mm CL but less than the minimum legal width of 120.7 mm measured outside the spines.

e Recruits are all legal newshell male crabs of minimum legal width but ≤ 115 mm CL.

f Postrecruits are all legal newshell male crabs > 115 mm CL, and all male anexuviants (skip molt crabs) that have obtained legal width.

g This crab could not be measured because it's carapace was damaged. It was classified as a ≤89mm CL crab but it could have been classified as a prerecruit one.

h The square nautical miles for these stations were calculated using a planimeter by ADF&G on NOAA chart 1620: Norton Sound to Bering Sea, 7/82 ed. Area calculated includes all ocean surface area greater than five fathoms.

Table 2. Comparison of red king crab catch data from 21 stations towed twice during the Norton Sound red king crab trawl survey conducted by the Alaska Department of Fish and Game, August 1996.

	Females		Males				
			Sublegal		Legal		
Survey Type[a]	Juv.	Adult	<89mm CL	Ones	Recruit	Postrecruit	Total
Initial Survey[b]	45	29	92	25	8	18	217
Resurvey[c]	51	19	99	18	5	9	201
Difference	+6	-10	+7	-7	-3	-9	-16

[a] The 21 stations towed twice are: 124-126, 130-134, 151-153, 157-161, and 183-187.

[b] Initial survey of the 21 stations occurred from August 8 to 12.

[c] Resurvey of the 21 stations occurred from August 15 to 18.

Table 3. Exoskeletal shell ages of male and female red king crabs from the Norton Sound red king crab trawl survey conducted by the Alaska Department of Fish and Game, August 1996.

	Shell Age Categories					
	Soft	New-Pliable	New-Hard	Old	Very Old	Total
Males						
Sublegals[a]	3	18	212	11	6	250
Legals[b]	3	7	13	15	29	67
Total	6	25	225	26	35	317
Percent	2%	8%	71%	8%	11%	100%
Females						
Juveniles[c]	1	3	99	0	0	103
Adults[d]	1	0	64	0	0	65
Total	2	3	163	0	0	168
Percent	1%	2%	97%	0%	0%	100%
Males						
Dead	5	16	29	0	3	53
Alive	1	9	196	26	32	264
Females						
Dead	2	1	16	0	0	19
Alive	0	2	147	0	0	149
Males and Females						
Ratio Dead:Alive	7:8	17:28	45:433	0:26	3:35	72:413
Percent Dead	88%	68%	10%	0%	9%	17%

[a] Male crabs < 120.7 mm carapace width (CW) outside the spines are sublegal.

[b] Male crabs ≥ 120.7 mm CW outside the spines are legal.

[c] Juvenile females include all females < 72 mm carapace length (CL) that were nonovigerous and had clean pleopodal setae.

[d] Adult females include all females ≥ 72 mm CL and any females with embryos or empty embryo cases.

Table 4. External reproductive conditions of female red king crabs observed on the Norton Sound red king crab trawl survey conducted by the Alaska Department of Fish and Game, August 1996.

Clutch and Embryo Categories	Shell Age Categories			Total
	Soft	New-pliable	New-hard	
Clutch				
Barren, clean setae	2	3	118	123[a]
Clutch 1-29% full	0	0	22	22
Clutch 30-59% full	0	0	8	8[b]
Clutch 60-89% full	0	0	24	24
Clutch 90-100% full	0	0	11	11
Total	2	3	163	168
Embryo Color				
Purple	0	0	37	37
Brown	0	0	2	2
Purple-brown	0	0	4	4
Reddish	0	0	1	1
Total	0	0	44	44
Embryo Development				
Uneyed	0	0	44	44
Eyed	0	0	0	0
Total	0	0	44	44
Dead Embryos				
Not Apparent	0	0	44	44
Less than 20%	0	0	0	0
Total	0	0	44	44

[a] Most (103) of the 123 females with barren, clean setae were juveniles (<72 mm CL).

[b] On initial inspection, one 68 mm CL female had a clutch of purple colored, uneyed embryos; however, following microscopic examination the embryos were in fact, eyed. A nereid-like polychaete was also found within the abdominal pouch of the same female.

Table 5. Ranking by total weight of each taxon identified in 69 tows made during the Norton Sound red king crab trawl survey conducted by the Alaska Department of Fish and Game, August 1996.

Common Name	Weight (kg)	Scientific Name or Taxon
Purple-orange sea star	9,411	*Asterias amurensis*
Saffron cod	2,546	*Eleginus gracilis*
Black-spined starfish	1,142	*Lethasterias nanimensis*
Starry flounder	847	*Platichthys stellatus*
Pacific halibut	784	*Hippoglossus stenolepis*
Plain sculpin	725	*Myoxocephalus jaok*
Giant sea star	639	*Evasterias echinosoma*
Yellowfin sole	533	*Pleuronectes asper*
Northern Whelk	506	*Neptunea heros*
Basket starfish	457	*Gorgonocephalus caryi*
Green sea urchin	376	*Strongylocentrotus droebachiensis*
Sea potato	355	*Styela rustica*
Hairy hermit crab	331	*Pagurus capillatus*
Fuzzy hermit crab	268	*Paurus trigonocheirus*
Alaska plaice	249	*Pleuronectes quadrituberculatus*
Red king crab	214	*Paralithodes camtschaticus*
Helmet crab	211	*Telmessus cheiragonus*
Stalked anemone	197	*Metridium senile*
Walleye pollock	169	*Theragra chalcogramma*
Sea glob	157	Aplidium sp.
Jellyfish unidentified	153	Scyophozoa
Fat whelk	148	*Neptunea ventricosa*
Knobby six-rayed sea star	118	*Leptasterias polaris*
Arctic sea star	114	*Leptasterias arctica*
Northern argid	88.0	*Argis lar*
Barnacle unidentified	84.9	Balanus sp.
Anemone	69.9	Tealia sp.
Snail eggs	67.8	Gastropoda
Notched brittle star	66.3	*Ophiura sarsi*
Tunicate unidentified	62.8	Ascidian
Rainbow smelt	57.7	*Osmerus mordax*
Threaded sculpin	52.7	*Gymnocanthus pistilliger*
Alaskan hermit crab	51.3	*Pagurus ochotensis*
Slender eelblenny	50.9	*Lumpenus fabricii*
Splendid hermit crab	43.3	*Labidochirus splendescens*
Pacific herring	42.7	*Clupea pallasi*
Sea raspberry	37.2	Gersimia sp.
Snow crab	30.3	*Chionoecetes opilio*

-Continued-

Table 5. (page 2 of 3)

Common Name	Weight (kg)	Scientific Name or Taxon
Warped whelk	28.0	*Pyrulofusus deformis*
Beaked barnacle	27.7	*Balanus rostratus*
Wattled eelpout	26.2	*Lycodes polearis*
Polar eelpout	20.6	*Lycodes turneri*
Circumboreal toad crab	19.3	*Hyas coarctatus*
Bering wolffish	17.5	*Anarhichas orientalis*
Sturgeon poacher	16.6	*Podothecus acipenserinus*
Leister sculpin	16.2	*Enophrys lucasi*
Northern beringius (snail)	16.2	*Beringius beringii*
Sand shrimp unidentified	13.7	Crangonidae
Longhead dab	12.4	*Limanda proboscidea*
Snail unidentified	10.7	Gastropoda
Flathead sole	10.3	*Hippoglossoides elassodon*
Rock sole	8.9	*Pleuronectes bilineatus*
Great sculpin	8.1	*Myoxocephalus polyacanthocephalus*
Greenspined sand dollar	8.0	*Echinarachnius parma*
Starfish unidentified	7.4	Asteroidea
Rose sea star	7.3	*Crossaster papposus*
Hermit crab unidentified	6.9	Paguridae
Bryozoan unidentified	6.3	Bryozoa
Cockle unidentified	6.0	Serripes sp.
Sponge unidentified	5.8	Porifera
Pighead prickleback	5.0	*Acantholumpenus mackayi*
Coonstripe shrimp	4.6	*Pandalus hypsinotus*
Nudibranch unidentified	4.5	Doridacea
Tank shrimp	4.4	*Sclerocrangon boreas*
Fourhorn sculpin	4.3	*Myoxocephalus quadricornis*
Arctic surfclam	4.2	*Mactromeris polynyma*
Humpy shrimp	3.9	*Pandalus goniurus*
Black mussel	2.9	*Musculus niger*
Scale worm unidentified	2.7	Eunoe sp.
Pacific cod	2.7	*Gadus macrocephalus*
Snailfish unidentified	2.4	Lycodes sp.
Bering poacher	2.3	*Ocella dodecaedron*
Sea onion	2.3	*Boltenia ovifera*
Blood star unidentified	1.9	Henricia sp.
Whitespotted greenling	1.9	*Hexagrammos stelleri*
Shortfin eelpout	1.8	*Lycodes brevipes*
Soft crab	1.7	*Hapalogaster grebnitzkii*
Sand shrimp	1.4	Crangon sp.

-Continued-

Table 5. (page 3 of 3)

Common Name	Weight (kg)	Scientific Name or Taxon
Crested sculpin	1.4	*Blepsias bilobus*
Eyeshade sculpin	1.1	*Nautichthys pribilovius*
Compound ascidian unidentified	1.1	Ascidiacea
Spiny lebbeid (shrimp)	1.0	*Lebbeus groenlandicus*
Worm unidentified	1.0	Polychaeta
Anemone unidentified	1.0	Actiniaria
Capelin	1.0	*Mallotus villosus*
Sand shrimp unidentified	0.8	Crangonidae
Macoma clam unidentified	0.8	Macoma sp.
Hydroid unidentified	0.7	Hydroida
Bent-nose macoma	0.5	*Macoma nasuta*
Smoothcheek sculpin	0.5	*Eurymen gyrinus*
Buccinum snail unidentified	0.5	Buccinum sp.
Arctic flounder	0.5	*Liopsetta glacialis*
Eelpout unidentified	0.5	Zoarcidae
Common crangon	0.5	*Crangon communis*
Natica moonsnail unidentified	0.4	Natica sp.
Starfish unidentified	0.4	Pteraster sp.
Whelk unidentified	0.4	Volutopsius sp.
Clam unidentified	0.3	Pelecypoda
Ribbed sculpin	0.3	*Triglops pingeli*
Coral unidentified	0.2	Anthozoa
Pandalus shrimp unidentified	0.2	Pandalus sp.
Polinices moonsnail unidentified	0.2	Polinices sp.
Daubed shanny	0.2	*Lumpenus maculatus*
Flattened bryozoan	0.2	*Porella compressa*
Ridged crangon	0.2	*Crangon dalli*
Poacher unidentified	0.2	Agonidae
Isopod	0.2	*Saduria entomon*
Brittle starfish unidentified	0.1	Ophiuridae
Argis shrimp unidentified	0.1	Argis sp.
Arctic shanny	0.1	*Stichaeus punctatus*
Sea cucumber unidentified	0.1	Holothuroidea
Cockle unidentified	0.1	Clinocardium sp.
Arctic hiatella (clam)	<0.1	*Hiatella arctica*
Amphipod unidentified	<0.1	Amphipod sp.
Total Weight:	21,617.2 kg	

Table 6. Pacific halibut, starry flounder, saffron cod, walleye pollock, and Pacific cod length frequencies from the Norton Sound red king crab trawl survey conducted by the Alaska Department of Fish and Game, August 1996[a].

Pacific Halibut		Starry Flounder		Saffron Cod		Walleye Pollock		Pacific Cod	
cm	No.	cm	No.	cm	No.	cm	No.	cm	No.
57	1	26	1	5	4	11	1	61	1
60	1	29	2	6	9	13	2	Total	1
61	1	30	2	7	8	14	2		
72	1	31	2	8	1	15	1		
73	1	32	3	12	2	16	2		
76	1	35	3	13	9	62	1		
77	2	36	4	14	25	65	2		
78	1	37	4	15	124	67	2		
80	3	38	3	16	182	68	2		
81	3	39	3	17	143	69	3		
82	4	40	4	18	62	70	3		
83	4	41	1	19	59	71	5		
84	1	42	5	20	97	72	1		
85	2	43	3	21	127	73	8		
86	2	44	4	22	138	74	3		
88	2	45	2	23	170	75	4		
89	2	46	4	24	148	76	8		
90	1	47	2	25	110	77	8		
91	2	48	1	26	69	78	1		
92	1	49	3	27	31	79	8		
93	5	50	1	28	12	81	1		
94	4	52	1	29	7	83	1		
95	2	54	1	30	2	84	1		
96	1	56	1	31	3	Total	70		
97	1	57	1	Total	1,542				
98	1	61	1						
99	1	Total	62						
100	2								
101	2								
102	1								
103	2								
104	3								
105	2								
106	1								
107	2								
108	1								
109	1								
110	1								
112	1								
113	1								
114	1								
118	1								
167	1								
Total	74								

[a] Fork length measured from tip of snout to fork of tail.

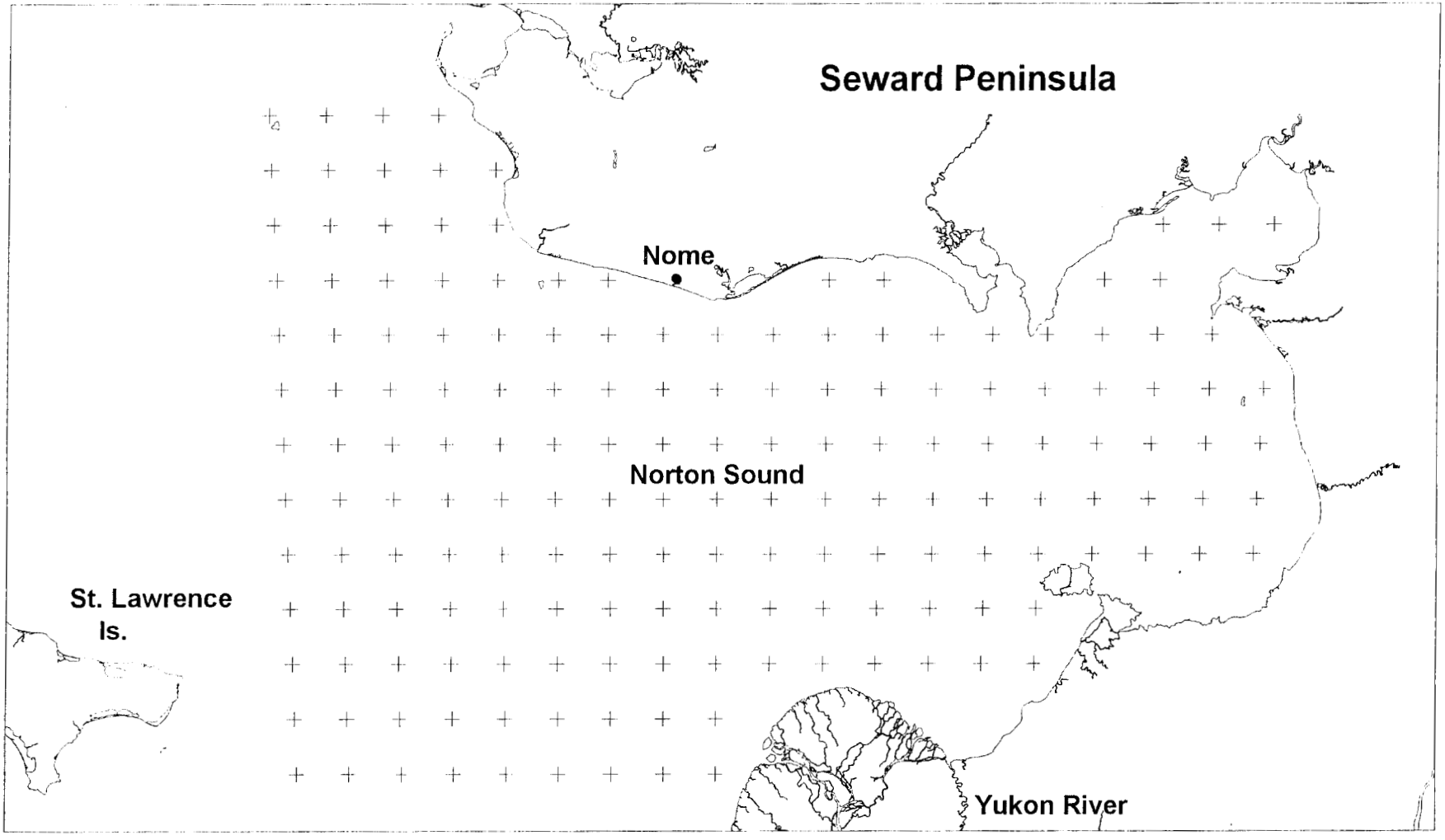


Figure 1. Trawl survey station centers used on the Norton Sound red king crab trawl survey conducted by the Alaska Department of Fish and Game, August 1996. Station centers are based on the 10 nmi x 10 nmi grid pattern used by National Marine Fisheries Service on trawl surveys of Norton Sound from 1976 to 1991.

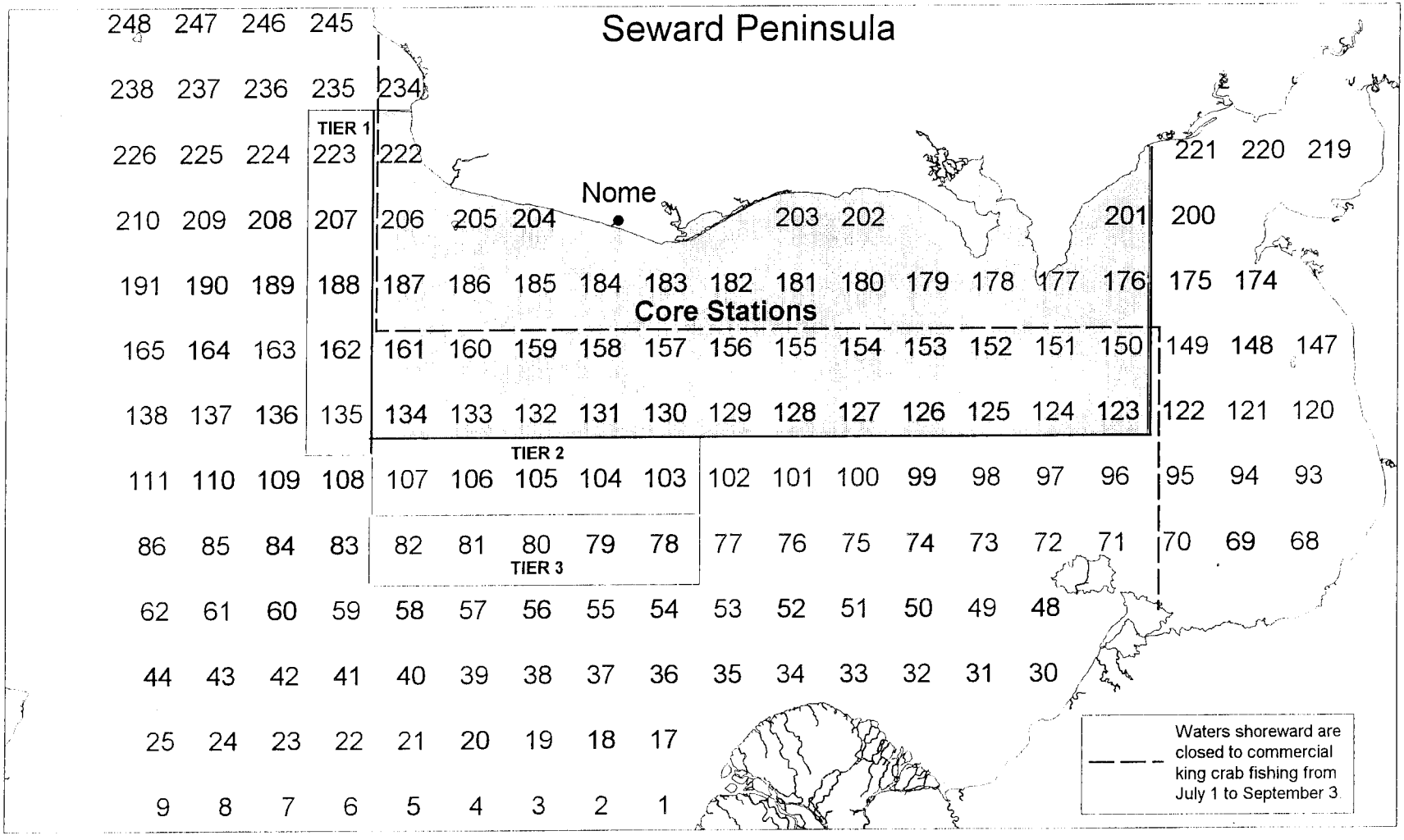


Figure 2. Layout of core and tier stations 1, 2, and 3 for the Norton Sound red king crab trawl survey conducted by the Alaska Department of Fish and Game, August 1996.

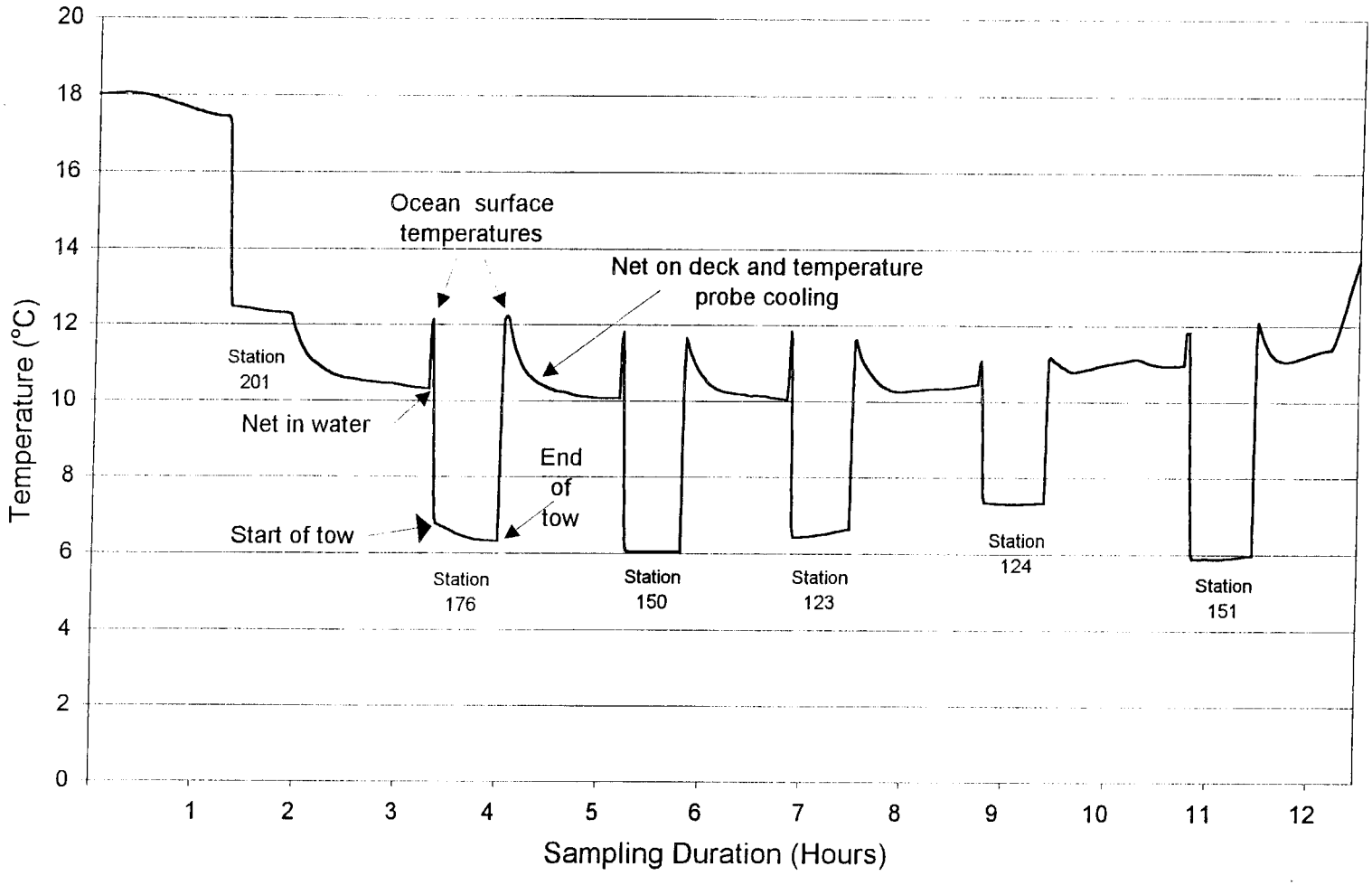


Figure 3. Temperature profiles from six stations towed on August 8, 1996 during the Norton Sound red king crab trawl survey conducted by the Alaska Department of Fish and Game.

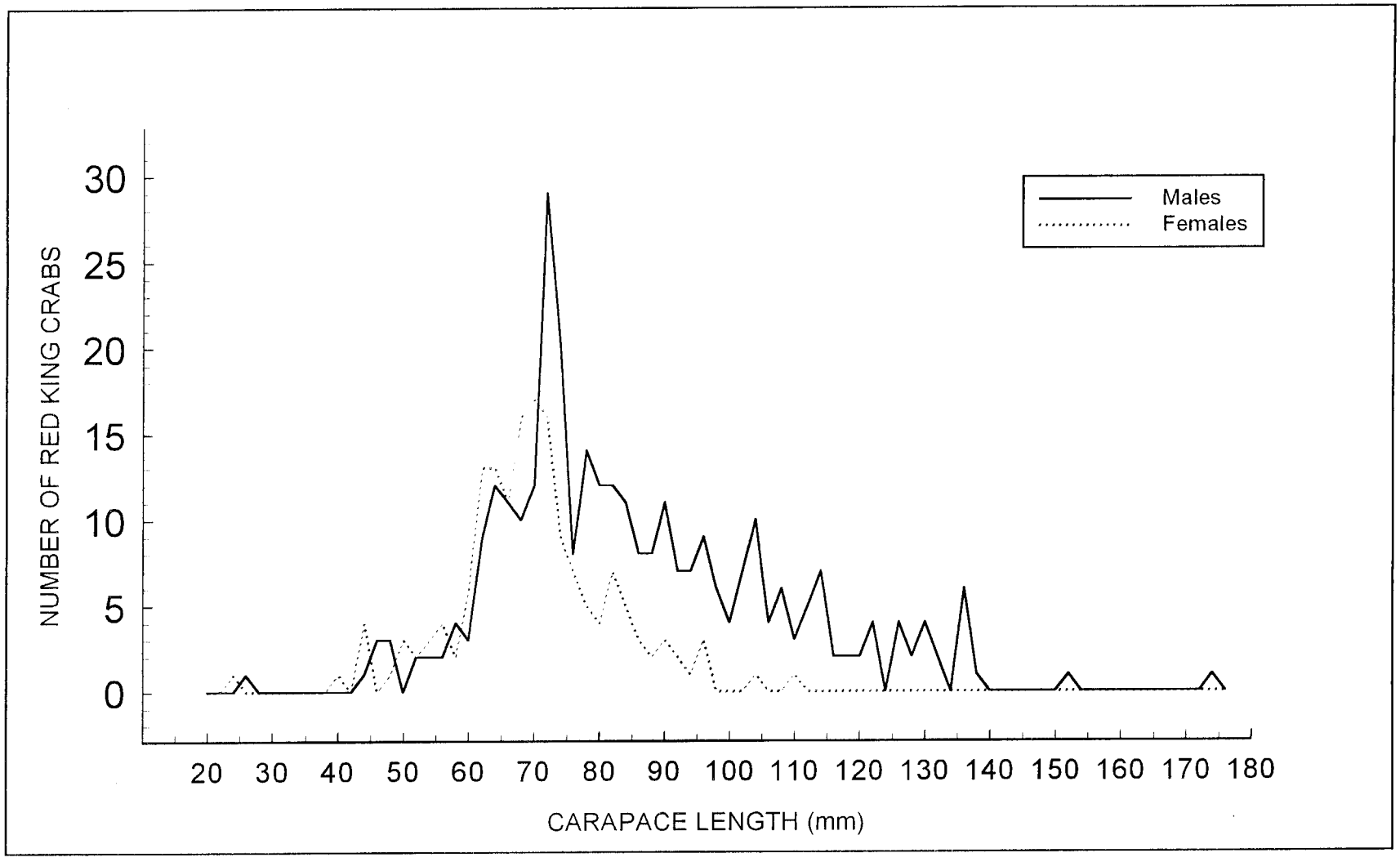


Figure 4. Carapace length frequencies of male (n=314) and female (n=166) red king crabs from the Norton Sound red king crab trawl survey conducted by the Alaska Department of Fish and Game in August 1996, grouped by 2-mm increments.

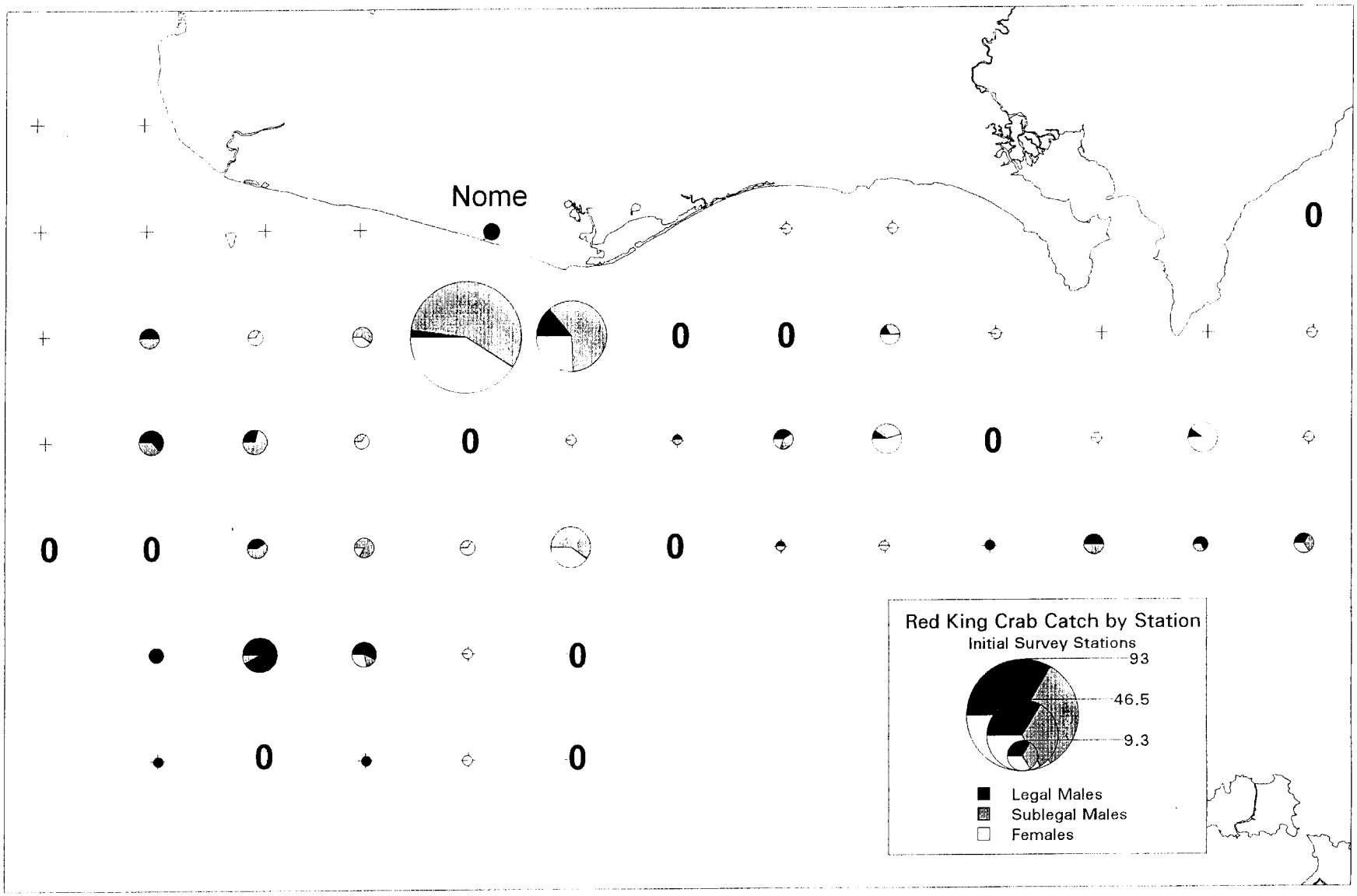


Figure 5. Catch of legal, sublegal, and female red king crabs by station from the 58 stations surveyed in the Norton Sound trawl survey conducted by the Alaska Department of Fish and Game, August 7-15, 1996. Note: '0' = no catch; '+' denotes untrawlable station. Distance towed varied between stations.

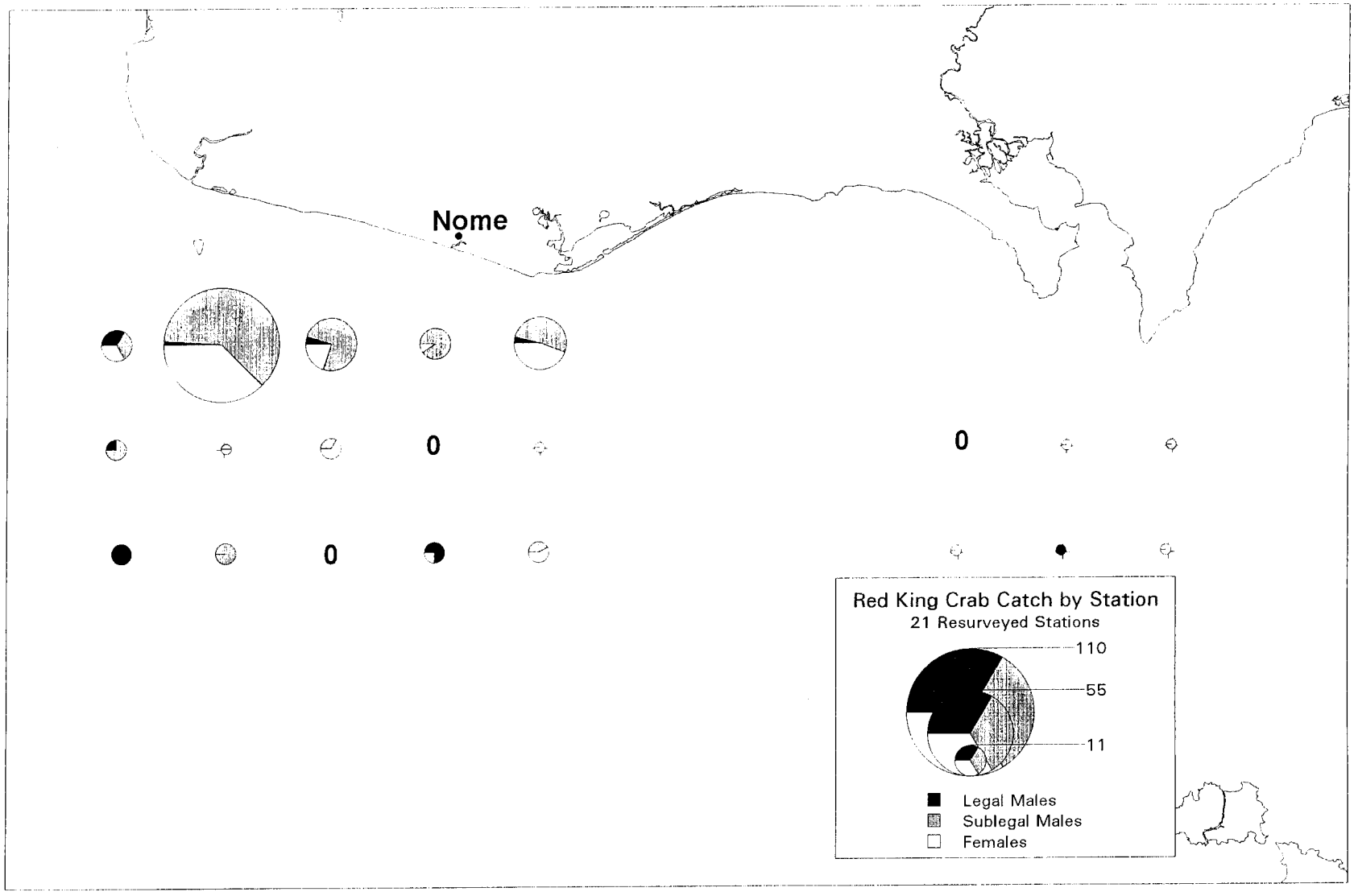


Figure 6. Catch of legal, sublegal, and female red king crabs by station from the 21 resurveyed stations in the Norton Sound trawl survey conducted by the Alaska Department of Fish and Game, August 15-18, 1996. Note: '0' = no catch. Distance towed varied between stations.

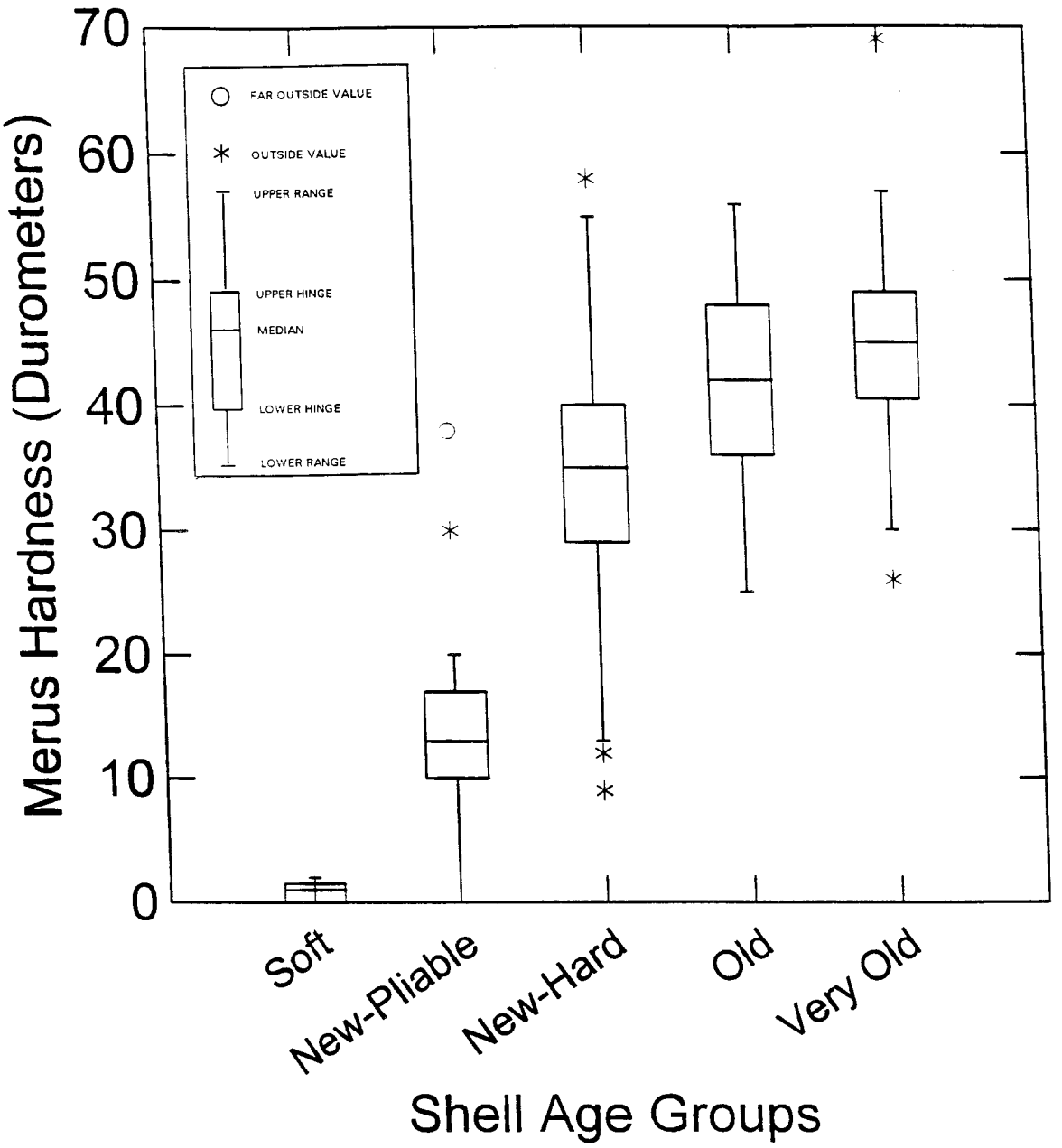


Figure 7. Box plots of merus hardness versus shell age groups taken from 467 red king crabs during the Norton Sound red king crab trawl survey conducted by the Alaska Department of Fish and Game, August 1996. "Upper hinge" corresponds to the 75th percentile of data; "lower hinge" corresponds to 25th percentile of data.

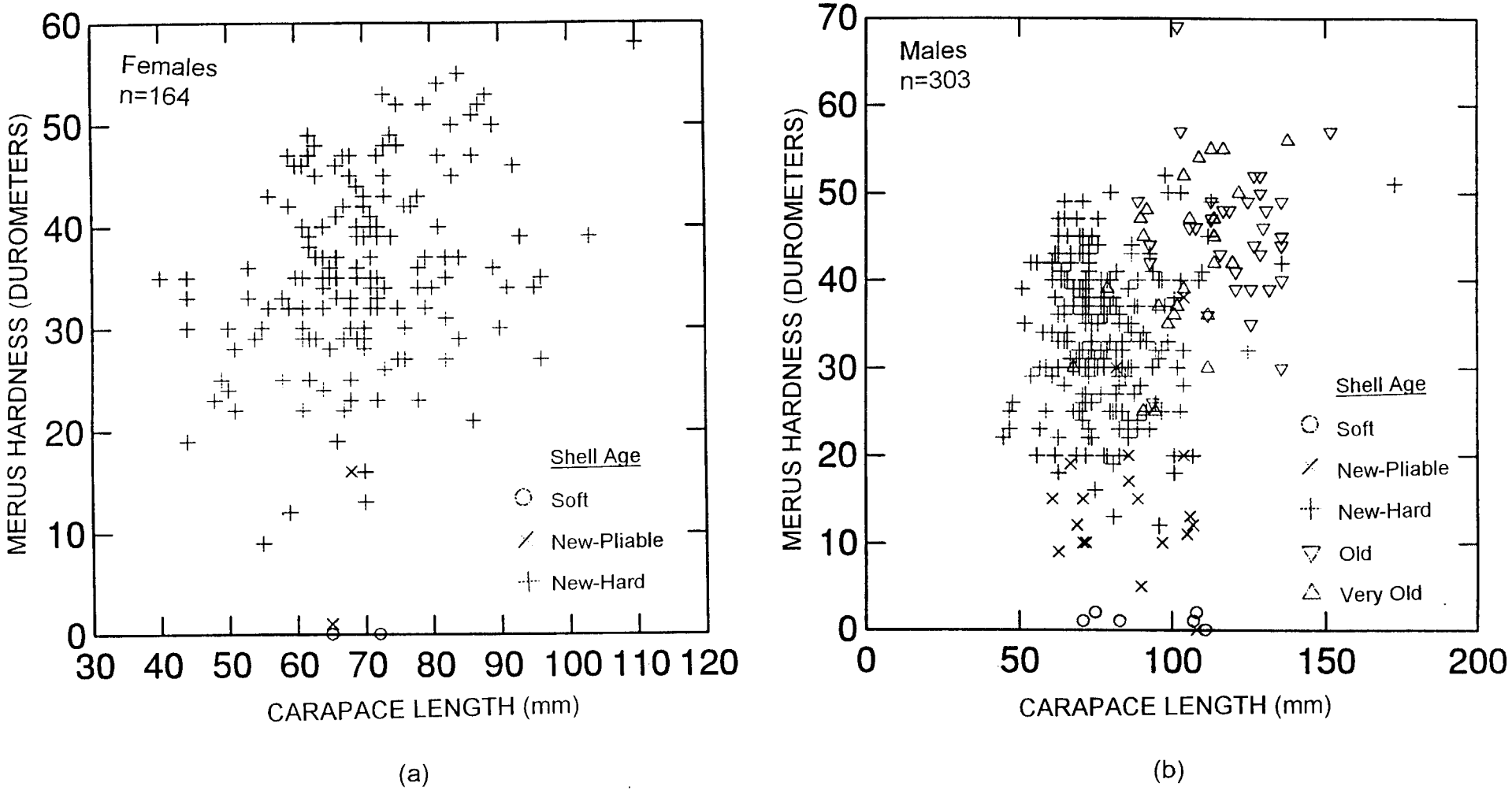


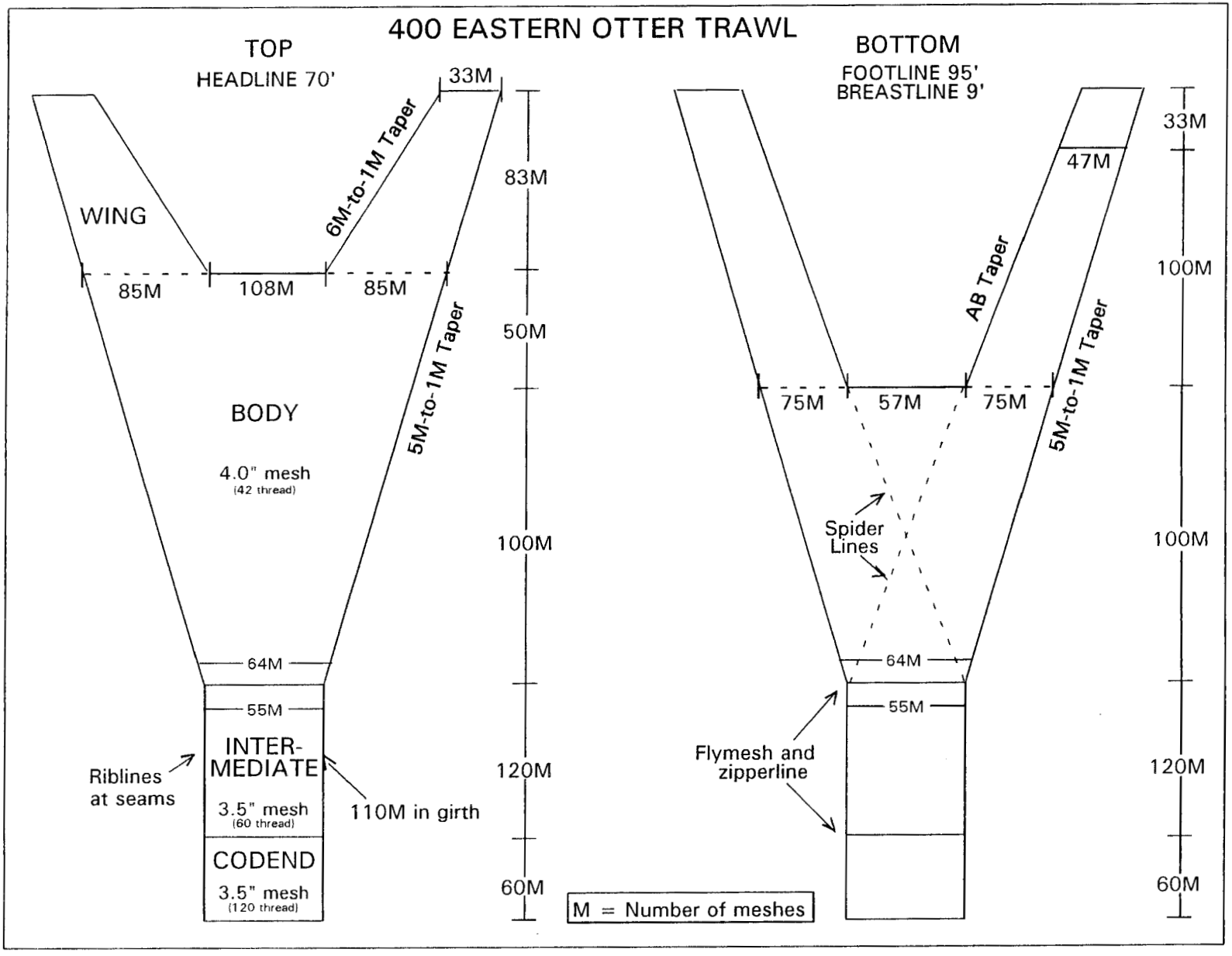
Figure 8. Merus hardness versus carapace length and shell age groups of (a) female and (b) male red king crabs captured during the Norton Sound trawl survey conducted by the Alaska Department of Fish and Game, August 1996.

APPENDIX

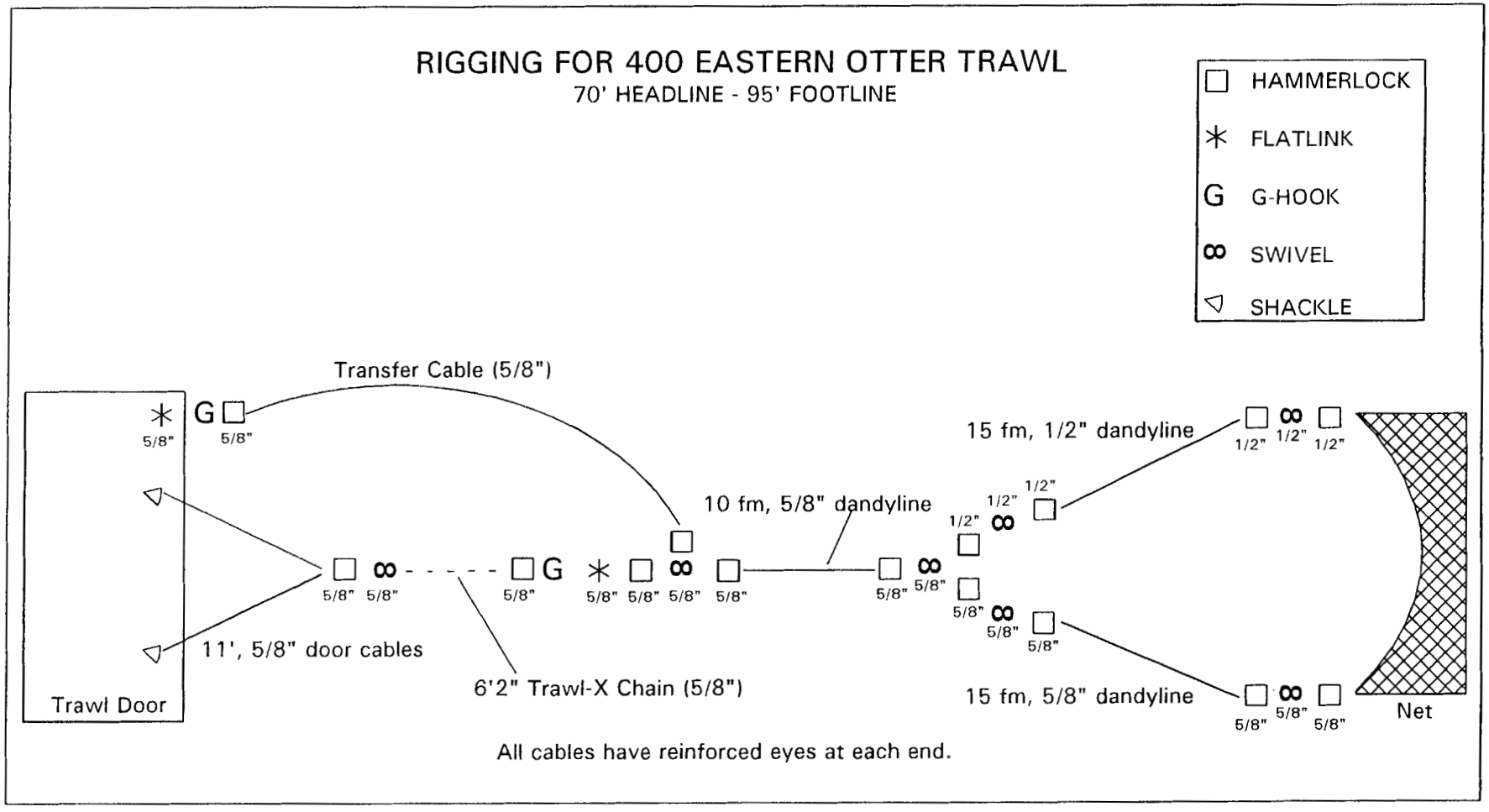
Appendix A.1. Description and diagrams of the 400 eastern otter trawl gear used on the Norton Sound red king crab trawl survey conducted by the Alaska Department of Fish and Game, August 1996.

A 400-mesh eastern otter trawl equipped with a 21.3-m (70-ft) headrope and a 29-m (95-ft) footrope with a target sweep of 12.2 m (40 ft) was used in the survey as described by Urban (1996). The headrope contained 18 floats each measuring 20.3 cm (8 in) in diameter. The footrope was weighted with 34.7 m (114 ft) of 1-cm (3/8-in) chain attached every 25.4 cm (10 in) to ensure that the footrope tended bottom. The trawl was constructed with 10.2-cm (4-in) stretch mesh at the mouth and wings, 8.9-cm (3.5-in) stretch mesh in the body and codend, and was fitted with a 3.2-cm (1.25-in) stretch mesh codend liner. The trawl was rigged with paired 45.7 m (25-fathom) galvanized wire rope dandylines. Each dandyline consisted of an 18.3-m (10-fathom) section of 1.6-cm (5/8-in) wire rope and a pair of 27.4-m (15-fathom) sections of 1.3-cm (1/2-in) wire rope, one attached to the top and the other to the bottom of each net wing. The net was fished using Astoria "V" type doors each weighing 340 kg (750 lb) and measuring 1.5 m x 2.1m (5 ft x 7 ft). Trawl and net rigging specifications are shown in Appendix A.2 and Appendix A.3, respectively.

Appendix A.2. Diagram of the 400 eastern otter trawl used on the Norton Sound trawl survey conducted by the Alaska Department of Fish and Game, August 1996.



Appendix A 3. Trawl rigging for the 400 eastern otter trawl used on the Norton Sound trawl survey conducted by the Alaska Department of Fish and Game, August 1996.



APPENDIX B.1. ADF&G trawl survey haul record - Norton Sound trawl survey form.

ADF&G TRAWL SURVEY HAUL RECORD - NORTON SOUND TRAWL SURVEY PG _____ OF _____

CAPTAIN: James Kasner VESSEL: PEGGY JO

SEQUENTIAL HAUL NUMBER	STATION NUMBER	VESSEL CODE	DATE			STARTING POSITION				COMPASS HEADING
			MO.	DAY	YEAR	N. LATITUDE DEG.	N. LATITUDE MINUTES	W. LONGITUDE DEGREE	W. LONGITUDE MINUTES	
						.		.		

TRAWL TIME			DIST. TOWED (NMI)	DEPTH (FM)			WEATHER (SEE CODES BELOW)			SCOPE (FM)	GEAR PERF.	BOTTOM TEMP. (C)
START	END	TOTAL (MIN)		MIN.	AVE.	MAX.	CLOUD	SEA	SWELL			
:	:		.									.

COMMENTS:

SEQUENTIAL HAUL NUMBER	STATION NUMBER	VESSEL CODE	DATE			STARTING POSITION				COMPASS HEADING
			MO.	DAY	YEAR	N. LATITUDE DEG.	N. LATITUDE MINUTES	W. LONGITUDE DEGREE	W. LONGITUDE MINUTES	
						.		.		

TRAWL TIME			DIST. TOWED (NMI)	DEPTH (FM)			WEATHER (SEE CODES BELOW)			SCOPE (FM)	GEAR PERF.	BOTTOM TEMP. (C)
START	END	TOTAL (MIN)		MIN.	AVE.	MAX.	CLOUD	SEA	SWELL			
:	:		.									.

COMMENTS:

WEATHER CODES						GEAR PERFORMANCE CODES	
CLOUD COVER		SEA STATE (FEET)		SWELL (FEET)			
Clear	1	0 to 2	1	0 to 2	1	Performance Unsatisfactory	01
1/8 obscured	2	2 to 4	2	2 to 4	2	Performance Satisfactory	20
1/4 obscured	3	4 to 6	3	4 to 6	3	Doors non-functional (collapsed, crossed)	21
3/8 obscured	4	6 to 8	4	6 to 8	4	Net non-functional (collapsed, torn, twisted, etc.)	22
1/2 obscured	5	8 to 10	5	8 to 10	5	Gear hung up on bottom	23
5/8 obscured	6	10 to 12	6	10 to 12	6	Trawl flipped or upside down	24
3/4 obscured	7	12 to 14	7	12 to 14	7	Mudded down	26
7/8 obscured	8	14 to 16	8	14 to 16	8	Telemetry malfunction (GPS,fathometer, etc.)	50
Completely overcast	9	Over 16	9	Over 16	9		

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APPENDIX B.2. ADF&G station catch record - Norton Sound trawl survey form.

ADF&G STATION CATCH RECORD - NORTON SOUND TRAWL SURVEY PG ___ OF ___

SEQUENTIAL HAUL NUMBER
STATION NUMBER

VESSEL: PEGGY JO
DATE:

(1) Gross catch weight (kg): _____
(2) Tare (kg): _____
(3) Net catch weight [(1) - (2)] (kg): _____
(4) Large Fish & Debris (kg): _____
(100% sample)

(5) Adjusted Net Catch Weight (3) or (3) - (4) (kg): _____
(6) Subsample Weight (kg): _____
(7) Raising Factor [(5)/(6)] (kg): _____

SPECIES NAME	SPECIES CODE					SAMPLE 1		SAMPLE 2		TOTAL CATCH	
						KILOS	NUMBER	KILOS	NUMBER	KILOS	NUMBER
Purple-orange starfish	8	1	7	4	2						
Saffron cod	2	1	7	3	5						
Plain Sculpin	2	1	3	7	1						
Yellowfin Sole	1	0	2	1	0						
Alaska plaice	1	0	2	8	5						
Red King Crab	6	9	3	2	2						
Helmet Crab	6	8	7	8	1						

file: restorm96.xls; sheet: catch96 ljw

APPENDIX B.3. ADF&G fish length frequency form - Norton Sound trawl survey.

ADF&G FISH LENGTH FREQUENCY FORM - NORTON SOUND TRAWL SURVEY

DATE: | 0 | 8 | | | 9 | 6 | PG _____ OF _____

VESSEL: PEGGY JO

SPECIES NAME	SEQ. HAUL NUMBER	SPECIES CODE	SIZE GROUP	FREQ	SPECIES NAME	SEQ. HAUL NUMBER	SPECIES CODE	SIZE GROUP	FREQ.

file: resfrm96.xls; sheet: fishfreq lyw

APPENDIX B.4. ADF&G crab research data form - Norton Sound trawl survey.

ADF&G CRAB RESEARCH DATA FORM - NORTON SOUND TRAWL SURVEY PG ____ OF ____

DATE: 0 8 ____ 9 6 MEASURER:_____

VESSEL: PEGGY JO RECORDER:_____

	SEQUENTIAL HAUL NUMBER	SPECIES	SEX	SIZE (CL-MM)	LEGAL	SHELL AGE	EMBRYOS: COLOR	EMBRYOS: DEVEL.	EMBRYOS: COND.	EMBRYOS: % CLUTCH	OTHER	DURO-METER	COMMENTS
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													

CRAB SPECIES
2-*P.camtschaticus*
3-*P.platypus*

LEGAL
1-Sublegal
2-Legal

RKC
<120.7mm(4.75")
≥120.7mm(4.75")

BKC
<139.7mm(5.5")
≥139.7mm(5.5")

SEX
1-Male
2-Female

SHELL AGE
0-Soft
1-New, pliable
2-New, hard
3-Old
4-Very old

OTHER
1-Dead
2-Alive
3-Nemerteans in clutch
4-Turbellarians in clutch
5-Black mat
6-Bitter crab disease
7-"Cottage cheese" disease
8-Shell rust (chitinoclastic bacteria)
9-*Briarosaccus callosus*

LIVE EGG COLOR
1-Tan
2-Purple
3-Brown
4-Orange
5-Purple-brn.
6-Pink
7-Reddish
0-Other; describe in comments.

EGG DEVEL.
1-Uneyed
2-Eyed

CLUTCH COND.
1-Dead eggs not apparent
2-Dead eggs <20%
3-Dead eggs ≥20%

PERCENT CLUTCH
1-Barren, clean pleopods
2-Barren, with empty embryo cases (matted setae)
3-Clutch 1-29% full
4-Clutch 30-59% full
5-Clutch 60-89% full
6-Clutch 90-100% full

file: resfrm96.xls; sheet: resfrm96 ljw

APPENDIX B.5. ADF&G daily station summary and radio log - Norton Sound trawl survey.

ADF&G DAILY STATION SUMMARY AND RADIO LOG - NORTON SOUND TRAWL SURVEY

PG ___ OF ___

VESSEL: PEGGY JO

RECORDER: ___

DATE		STATION	AVERAGE	RED KING CRABS									BLUE KING CRABS				RADIO CALL
				FEMALES			MALES						FEMALES	MALES			
							SUBLEGALS			LEGALS							
MO.	DAY	OR HAUL NO	DEPTH (FM)	JUV.	ADULTS	TOTAL	<89mm	PREONES (≥89MM)	TOTAL	RECRUITS (≥104-115mm)	POST REC.	TOTAL		SUB-LEGALS	LEGALS	TOTAL	
Col. 1	Col. 2	Col. 3				Col. 4			Col. 5			Col. 6	Col. 7			Col. 8	

file: resfrm96; sheet: statsum96 ljw